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Association of sleep quality and quality of life in type 2 diabetes mellitus: A cross-sectional study in China

Peian Lou [a], *Yu Qin* [b,*], *Pan Zhang* [a], *Peipei Chen* [a], *Lei Zhang* [a], *Guiqiu Chang* [a], *Ting Li* [a], *Cheng Qiao* [a], *Ning Zhang* [a]

[a] *Department of Control and Prevention of Chronic non-communicable diseases of Xuzhou Center for Disease Control and Prevention, Xuzhou, China*

[b] *Jiangsu Provincial Center for Disease Control and Prevention, Nanjing, China*

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ABSTRACT

Objective: The aim of this study is to investigate sleep quality and quality of life, and to assess the relationship between sleep quality and quality of life in Chinese patients with type 2 diabetes mellitus (T2DM).

Research design and methods: 944 patients with T2DM were enrolled in our study. General characteristics and laboratory testing such as glycosylated hemoglobin A1c (HbA1c) were measured. Each patient completed a Chinese version of the Pittsburgh sleep quality index (PSQI) and the diabetes specificity quality of life scale (DSQL) questionnaires. A PSQI global score >7 was defined as poor sleep quality. A global DSQL score <40 was defined as a good quality of life. Multiple logistic regression analysis was used to examine the relationships between PSQI and DSQL.

Results: Poor quality of life in participants was associated with a longer duration of diabetes, a greater number of diabetes complications, no alcohol drinking, poor glycemic control and having depression and anxiety (all $P < 0.001$). Of the participants, 33.6% of them were poor sleepers according to their PSQI. Poor sleepers had significantly lower DSQL ($P < 001$). After adjustment for confounders, poor sleep quality was positively associated with a lower health-related quality of life (OR: 3.67, 95% CI: 1.30–10.33, $P < 0.001$).

Conclusions: Our results suggest that poor sleep is prevalent in T2DM and inversely associated with quality of life. It is necessary for primary health-care workers to include sleep related knowledge in diabetes self-management programs to improve sleep quality in diabetes patients.

* Corresponding author. Tel.: +86 25 83759415.
E-mail addresses: lpa82835415@126.com (P. Lou), qinyu@jscdc.cn (Y. Qin), xzzhangpan@126.com (P. Zhang), 71772690@qq.com (P. Chen), 18905218811@189.cn (L. Zhang), 1548857561@qq.com (G. Chang), nfykliting@126.com (T. Li), qc101273528@126.com (C. Qiao), 494174@qq.com (N. Zhang).

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1. Introduction

Type 2 diabetes mellitus (T2DM) is a major chronic disease with significant implications for the global society and economy. Because of rapid lifestyle changes, the prevalence of T2DM has increased dramatically in recent years and is now reaching epidemic proportions, resulting in a serious public health issue in China [1,2]. T2DM has detrimental effects on health outcomes including quality of life (QoL) outcomes [3] and studies have shown significant negative associations for health related quality of life (HRQL), being one specific aspect of QoL, with prognosis of T2DM [4,5]. Thus, further understanding the determinants of HRQL and QoL among individuals with T2DM would be important to tailor and target intervention strategies to improve these outcomes for the T2DM population group.

Several studies has found that aging, low income, a lower score on activity (personality) traits, insulin use, increased morbidities, a higher body mass index, smoking, being female and depressive symptoms were significantly associated with poor HRQL in adults with T2DM [6–8]. Meanwhile, more and more studies have shown poor sleep has been a common feature of T2DM [9–11], even in age- and sex-matched controls [12] and that poor sleep quality has decreased the quality of life in T2DM patients [13–15]. However, these findings were based on management of T2DM patients who attended the Specialist Outpatient Departments of General Hospitals rather than population-based representative samples of all T2DM patients.

In China, patients with T2DM reached above one hundred million in 2010 [1], and the rate of glycemic control of T2DM was only 16.8% [16]. The prevalence of poor sleep quality was 49.3% using PSQI ≥ 5 as a cutoff [11], however, this cutoff did not fit the Chinese population [17].Tsai et al. [14] indicated a reciprocal interaction between poor sleep and worse glycemic control in T2DM patients. However, the relationship between quality of life and sleep quality has not been reported in the Chinese T2DM population. Therefore we conducted a representative population-based cross-sectional study targeting diagnosed T2DM in a Chinese population during August to December 2012. The objectives of this present study were to investigate sleep quality and quality of life in the T2DM population and to assess the relationship between sleep quality and quality of life in Chinese patients with T2DM.

2. Patients and methods

Xuzhou City is a medium-developed city of nine million in eastern China where the diabetes registry system covers all communities. The sampling was selected with probability proportional to size from all of the eleven regions in the study area. In the first stage, 5 sub-districts in urban areas or townships in rural areas were selected from each site with probability proportional to size. In the second stage, 5 neighborhood communities or administrative villages were selected with probability proportional to size based on the number of diabetic patients. In the final stage, patients with diabetes who meet the inclusion criteria and registered in the health centers were selected according to the medical records. At least 900 people were selected assuming an estimation prevalence of poor sleep quality of 30% in patients with T2DM [18] with a 90% power and $\alpha = 0.05$ and allowing for a drop-out of 10%. The study was conducted between August and December 2012.

2.1. *Inclusion and exclusion criteria*

T2DM was diagnosed according to the recommendations of the American Diabetes Association [19]. Subjects who were diagnosed with T2DM by physicians at least six months prior using baseline clinical information and laboratory data were recruited in our study. Exclusion criteria were as follows: (1) type 1 diabetes; (2) painful diabetic sensory neuropathology; (3) diagnosed sleep disorders prior to diabetes; (4) mental illness or use of any kind of psychotropic medication; (5) working in nights shifts in the last 3 months or travelling across time zones within one month; (6) other endocrine disorders, such as, thyroid disease or chronic use of glucocorticoids; (7) age <18 years; (8) pregnancy or lactation.

A total of 1000 eligible T2DM patients aged 27–97 years old were invited into the study. Among them 31 patients dropped out due to working, 16 patients refused to take part in the study, and nine patients failed to complete the questionnaire. The response rate was 94.4%. Overall, 944 T2DM patients were involved in the study.

Written informed consent was obtained from all participants. The study protocol was approved by Xuzhou Center for Disease Control and Prevention.

2.2. *Sleep quality*

Sleep quality was measured using the Pittsburgh sleep quality index (PSQI) [20]. The PSQI is a 19-item self-report measure of sleep quality and degree of sleep difficulties over the past month and contains 7 component scales: sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbances, use of sleep medication and daytime dysfunction. The 7 component scores are then summed to yield a global PSQI score with a range of 0-21; higher scores indicate worse sleep quality. The Chinese version of the PSQI used in this study has been approved by the original PSQI authors. A global PSQI score over 7 had a diagnostic sensitivity of 98.3% and specificity of 90.2% in distinguishing normal subjects from patients with sleep quality problems .The good clinical practice and metrical properties of PSQI suggest its utility both in Chinese psychiatric clinical practice and research activities [17]. Accordingly, in our study, a PSQI score <7 and $\geq$8was defined as 'good sleep quality' and 'poor sleep quality', respectively.

2.3. *Diabetes specificity quality of life scale (DSQL)*

Quality of life was measured using the diabetes specificity quality of life scale (DSQL) which is a validated questionnaire developed by Chen et al. [21] to assess life quality of T2DM patients in China. The scale includes twenty-four items with four domain scores which reflect problems of quality of life in the areas of physiology, psychology, social and therapy. The

sum of the scores for these four components produces a global quality of life score with a range of 24–120 points, higher scores indicating worse quality of life. A DSQL score <40 had a diagnostic sensitivity of 94.5% and specificity of 91.0% in differentiating good from poor quality of life [21].

2.4. Other variables

Age, gender, marriage status, physical activities, net household income, level of education, cigarette smoking, alcohol consumption, years since diabetes diagnosed, number of comorbidities, number of diabetic complications and insulin use were assessed using a standardized questionnaire. The number of diabetic complications was determined by assessing whether participants reported their diagnosed coronary artery disease, peripheral vascular disease, stroke, nephropathy, retinopathy, or neuropathy. All fasting venous blood samples were drawn between 8:00 AM and 9:00 AM. HbA1c level was assayed using high-performance liquid chromatography (BIO-RAD Diagnositic Group, CA, USA). We used the level of HbA1c as the index for glycemic control in T2DM patients in the study. The level of HbA1c $\leq$ 6.5% (48 mmol/mol) was defined as good glycemic control based on the Chinese Type 2 Diabetes Prevention and Control 2010 Guidelines while a level of HbA1c > 6.5% was considered poor glycemic control [22]. Body height (to the nearest 0.1 cm) and weight (to the nearest 0.1 kg) in light indoor clothing were measured. Body mass index (BMI; in kg/m^2) was calculated, and categorized as underweight (<18.5 kg/m^2), normal weight (18.5–23.9 kg/m^2) and overweight/obese ($\geq$24.0 kg/m^2) [23].

2.5. Self-rating depression scale

Anxiety and depression was assessed by The self-rating anxiety scale (SAS) and self-rating depression scale (SDS), respectively [24], these being valid and reliable instruments for the Chinese population [25]. Each of the two scales included 20 questions and each question scored from 1 to 4 to reflect frequency (1, rarely; 2, some of the time; 3, very often/often; 4, almost always). The total score of the 20 questions was multiplied by 1.25, with the integer score as a standard score. The standard score below 50 was considered as without anxiety or depression.

2.6. Statistical analysis

Statistical analysis was performed using the statistical software SPSS 13.0 (SPSS, Chicago, USA). Continuous variables were presented as a mean $\pm$ standard deviation, and categorical variables were presented as percentages. Student's *t*-test and the χ^2 test were used to compare differences in the continuous and categorical variables, respectively. Spearman correlation coefficients were used to examine associations between continuous variables. The Mann–Whitney *U* test was used for variables that were not normally distributed. Logistic regression analysis was used to examine the relationship between sleep quality and DSQL by adjustment for covariates, such as age, gender, educational level, marriage status, physical activities, net household income, BMI, number of comorbidities, diabetes duration, number of diabetic complications, insulin use, level of HbAc1, depressive symptoms, anxiety, cigarette smoking and alcohol consumption. The odds ratios (OR) and 95% confidence intervals (CI) were determined for all variables. Values of $P < 0.05$ were considered statistically significant.

3. Results

The mean age of participants was 64.1 $\pm$ 10.2 years, and 61.3% were female. The mean age of non-respondents was 63.8 $\pm$ 10.1 years, and 59. 9% were female. There were no significant differences between participants and non-respondents ($P > 0.05$).

Among the participants 17.3% were smokers, 12.0% were alcohol drinkers, 40.1% had depressive symptoms and 65.5% had anxious symptoms. Of participants 64.2% did not have any comorbidity, and 12.4% were treated with insulin. Participants had an average duration 5.6 $\pm$ 5.1 years since T2DM had been diagnosed. The distribution of general characteristics of the participants was presented in Table 1.

3.1. Sleep quality

The mean global PSQI score was 6.87 $\pm$ 3.84. Males had lower average scores than females (6.07 $\pm$ 3.35 vs. 7.27 $\pm$ 3.91, $P < 0.01$). The scores of 7 domains from highest to lowest were sleep latency (1.32 $\pm$ 0.98), sleep disturbances (1.18 $\pm$ 0.57), subjective sleep quality (1.17 $\pm$ 0.78), habitual sleep efficiency (0.86 $\pm$ 1.10), daytime dysfunction (0.65 $\pm$ 0.89), sleep duration (0.51 $\pm$ 0.85) and use of sleep medications (0.12 $\pm$ 0.44). The prevalence of poor sleep was 33.6%, and poor sleepers had significantly poorer DSQL ($P < 0.01$) (Table 1). There were no difference in insulin use between good and poor sleepers ($P > 0.05$).

3.2. Quality of life

The average DSQL was 50.7 $\pm$ 12.9, and males had a lower DSQL than females (48.8 $\pm$ 12.7 vs. 51.9 $\pm$ 13.1, $P < 0.01$). Table 2 listed the risk factors for quality of life in T2DM patients. Compared with the participants with good quality of life, participants with poor quality of life had poorer sleep quality. Compared to participants with good quality of life, those with poor quality of life were older, drank more alcohol, had a longer duration of diabetes and a greater number of comorbidities, diabetic complications and depressive and anxiety symptoms. Participants with insulin use had a poorer DSQL than those without insulin use (Table 2).

3.3. Sleep quality and quality of life

Unconditional multivariate logistic regressions on the association between sleep quality and DSQL were presented in Table 3. Sleep quality was significantly related to DSQL (OR = 3.67, 95%CI: 1.30–10.33, $P < 0.001$), by adjustment for confounders. Participants being female and with more diabetes-related complications, depressive symptoms, anxiety symptoms and a long diabetes duration had a positive relationship with DSQL. Those having a lower HbA1c level and

Table 1 – The distribution of general characteristics of the participants.

Variables	All ($n = 944$)	Sleep quality		P
		Good (627)	Poor (317)	
Sex (female)	579 (61.3)	364 (58.1)	215 (67.8)	0.004
Age (years)	64.1 ± 10.2	62.8 ± 10.0	66.5 ± 10.2	<0.01
Above high school	88 (9.3)	68 (10.8)	20 (6.3)	<0.01
No spouse	155 (16.4)	76 (12.1)	79 (24.9)	<0.01
Regular exercise	754 (79.9)	519 (82.8)	235 (74.1)	0.28
Income below population average (%)	489 (51.8)	321 (51.2)	168 (53.0)	0.601
BMI, mean (SD)	23.9 ± 2.7	23.8 ± 2.7	24.0 ± 2.8	0.609
Median of disease duration (years)	5.6 ± 5.1	5.1 ± 4.6	6.8 ± 5.7	<0.01
Comorbidities	338 (35.8)	197 (31.4)	141 (44.5)	<0.01
Complications	239 (25.3)	126 (20.1)	113 (35.6)	<0.01
Smokers	163 (17.3)	114 (18.2)	49 (15.5)	0.296
Drinkers	113 (12.0)	86 (13.7)	27 (8.5)	0.020
Depression	379 (40.1)	198 (31.6)	181 (57.1)	<0.01
Anxiety	618 (65.5)	351 (35.1)	267 (84.2)	<0.01
Using insulin	117	75 (12.0)	42 (13.2)	0.571
HbA1c < 6.5%	164 (17.4)	107 (17.0)	57 (17.9)	0.761
DSQL	50.7 ± 12.9	47.6 ± 10.7	56.9 ± 14.5	<0.01

BMI: Body mass index; HbA1c: glycated hemoglobin; DSQL: diabetes specificity quality of life scale. Comorbidities refers to disease accompanied diabetes; Complication refers to a disease caused by diabetes

with alcohol consumption had a negative relationship with DSQL.

The correlation coefficients between mean scores of global PSQI of 7 domains and DSQL total score ranged from 0.11 to 0.37. There was a positive correlation between global PSQI and quality of life in T2DM patients (Table 4).

Among the components of the PSQI, subjective sleep quality, sleep latency, sleep efficiency, and sleep disturbance were significantly associated with DSQL. In particular for sleep disturbances and DSQL, each one point increase in sleep disturbances score was associated with a 3.89-fold increase in risk of poor DSQL (OR:3.89, 95% CI:2.81–5.39, $P < 0.001$) (Table 5).

4. Discussion

To our knowledge, this is the first representative population-based study to investigate the association between poor sleep and quality of life in T2DM in China. Using a validated measure of self-reported sleep quality, we found that more than a third (33.6%) of the participants had poor sleep quality. Poor

Table 2 – The general characteristics of quality of life of the participants.

Variables	All ($n = 944$)	Quality of life		P
		Good ($n = 188$)	Poor ($n = 756$)	
Sex (women)	579 (61.3)	70 (12.1)	509 (87.9)	<0.01
Age	64.1 ± 10.2	61.0 ± 11.6	64.8 ± 9.7	<0.01
Above high school	88 (9.3)	19 (10.1)	69 (9.1)	0.662
No spouse	155 (16.4)	26 (13.8)	129 (17.1)	0.284
Regular exercise	824 (87.3)	165 (87.76)	589 (87.16)	0.826
Income below population average (%)	489 (51.8)	95 (50.5)	394 (52.1)	0.697
BMI, mean (SD)	23.9 ± 2.7	24.3 ± 2.5	23.8 ± 2.8	0.727
Median of disease duration (years)	5.6 ± 5.1	3.8 ± 3.7	6.1 ± 5.3	<0.01
Comorbidities	338 (35.8)	47 (25.0)	291 (38.5)	<0.01
Complications	239 (25.3)	13 (6.9)	226 (29.9)	<0.01
Smokers	163 (17.3)	37 (19.7)	126 (16.7)	0.328
Drinkers	113 (12.0)	34 (18.1)	79 (10.4)	<0.01
Depression	379 (40.1)	50 (26.6)	329 (43.5)	<0.01
Anxiety	618 (65.5)	86 (45.7)	532 (70.4)	<0.01
Using insulin	117 (12.4)	6 (3.2)	111 (14.7)	<0.01
HbA1c <6.5%	164 (17.4)	60 (29.6)	104 (13.8)	<0.01
PSQI	6.87 ± 3.84	4.55 ± 2.61	7.45 ± 3.84	<0.01

BMI: body mass index; HbA1c: glycated hemoglobin; DSQL: diabetes specificity quality of life scale. Comorbidity refers to disease accompanied diabetes; Complication refers to a disease caused by diabetes; PSQI: Pittsburgh sleep quality index.

Table 3 – Logistic regression analysis for sleep quality predicting DSQL.

Variables	β	S.E.	OR	95%CI	P
Diabetes-related complications (yes)	1.90	0.66	6.68	1.83–14.43	<.0.01
PSQI (≥8)	1.31	0.53	3.67	1.30–10.33	<0.01
Depression (yes)	1.72	0.47	5.61	2.25–14.02	<0.01
Females	1.12	0.41	3.06	1.36–6.91	0.01
Anxiety (yes)	1.63	0.52	5.12	1.84–14.22	<0.01
HbA1c level (<6.5%)	−1.61	0.51	0.21	0.07–0.55	<0.01
Duration of diabetes (year)	0.18	0.08	1.19	1.02–1.40	0.03
Drinking (yes)	−1.41	0.66	0.24	0.07–0.89	0.03
Age (year)	0.07	0.03	1.04	0.933–1.12	0.08
Smoking (yes)	−0.20	0.29	0.82	0.46–1.46	0.50
Education level (high school)	0.01	0.01	1	0.98–1.02	0.85
Marriages (yes)	0.05	0.05	1.01.	0.89–1.08	0.78
Regular exercise (yes)	0.01	0.12	1.05	0.81–1.27	0.93
Income below population average (%)	−0.67	0.59	0.51	0.16–1.62	0.25
BMI (≥24)	0.17	0.19	1.18	0.82–1.74	0.38
Comorbidities (yes)	0.59	0.47	1.81	0.73–4.51	0.20
Using insulin (yes)	0.42	0.52	1.52	0.55–4.22	0.43

BMI: body mass index; HbA1c: Glycated hemoglobin; DSQL: diabetes specificity quality of life scale. Comorbidity refers to disease accompanied diabetes; Complication refers to a disease caused by diabetes; PSQI: Pittsburgh sleep quality index.

sleepers tended to be older, female, had more comorbidities and complications, and had higher levels of anxiety and depressive symptoms compared with good sleepers. Furthermore, poor sleepers had a worse diabetes-related quality of life, including the DSQL total score and the physiology, psychology, social and therapy subscales. These findings suggest that poor sleep quality may adversely affect diabetes-related quality of life in T2DM patients.

The total PSQI mean score of our study was higher than that of two other studies [11,14], and lower than that from Seligowski et al. [15]. However, the proportion of poor sleep quality in our study was inconsistent with the previous studies which showed 52–71% of T2DM patients with poor sleep quality [9,10,13]. The lower proportion of poor sleep quality in our study may be attributed to different cutoffs for definition of poor sleep quality and different sampling among the studies. Our study showed that poor sleep quality was associated with poor quality of life in T2DM patients, consistent with other reports. The PSQI score was significantly higher in females than in males in our study, which was consistent with other reports [11,26]. The poorer sleep quality contributed more to poorer quality of life in women

Table 4 – Relationship between seven component scores and total scores of PSQI and four domains scores and total score of DSQL with Person correlation analysis (*r*).

Dimensions	Physiology	Psychology	Social	Therapy	Total DSQL scores
Subjective sleep quality	0.337*	0.254*	0.103*	0.142*	0.318*
Sleep latency	0.279*	0.208*	0.074#	0.187*	0.269*
Sleep duration	0.192*	0.148*	−0.088*	0.053	0.151*
Habitual sleep efficiency	0.222*	0.133*	−0.086*	0.049	0.164*
Sleep disturbances	0.375*	0.282*	0.192*	0.213*	0.375*
Use of sleep medications	0.346*	0.263*	0.244*	0.206*	0.363*
Daytime dysfunction.	0.081	0.057	0.161*	0.128*	0.110*
Global PSQI scores	0.407*	0.293*	0.102*	0.202*	0.367*

* $P < 0.01$.
\# $P < 0.05$.

Table 5 – Logistic regression analysis of PSQI components and DSQL.

	β	SEβ	OR	95% CI	P value
Subjective sleep quality	1.21	0.32	3.34	1.79–6.23	<0.00
Sleep latency	0.51	0.30	1.63	1.02–3.28	0.04
Sleep duration	0.09	0.04	1.10	0.98–1.19	0.08
Sleep efficiency	0.62	0.14	1.87	1.42–2.45	<0.00
Sleep disturbances	1.36	0.17	3.89	2.81–5.39	<0.00
Use of sleep medications	0.02	0.04	1.02	0.93–1.10	0.66
Daytime dysfunction	0.06	0.13	1.06	0.82–1.37	0.64

Adjustment for age, sex, education level, marriage status, exercise, household income, BMI, number of comorbidities, diabetes duration, number of diabetic complications, insulin use, level of HbAc1, depressive symptoms, anxiety, cigarette smoking and alcohol drinking.

than in men. In the seven components of the PSQI questionnaire, subjective sleep quality, sleep latency, sleep efficiency and sleep disturbances were significantly associated with DSQL. The sleep duration, use of sleep medications and daytime dysfunction were not significantly associated with DSQL. Diabetes-related complications may have substantial impact on health-related quality of life [27–29]. Although the duration of diabetes was a risk factor for poor quality of life in an earlier study [30], the finding may be because patients with diabetes of long duration were more likely to suffer from a greater number of diabetes-related complications and poorer glycemic control [31] these being associated with poor quality of life, rather than duration of diabetes itself.

In the present study, DSQL was significantly associated with sleep disturbance, the four domains' scores of DSQL were associated with total PSQI score, suggesting that sleep quality may have an important role in the way that psychological distress affects diabetes related quality of life [15]. This is in agreement with previous data showing that depressed or anxious diabetic patients had lower quality of life [32,33]. On the other hand, depression and anxiety was not only associated with poorer glycemic control [34], but also with decreased diabetes-specific quality of life, independent of glycemic control and complications [15,35,36]. These findings were consistent with our results.

In the current study, the glycemic control rate in diabetic patients was only 17%, which was lower than the other international reports (35–59%) [37–40]. Maintaining good glycemic control could reduce the risk of complications. Since these complications are known to reduce HRQL, intensified glycemic control is expected as an important way to reduce risk of complications and improve HRQL [41]. Our study showed that patients with higher HbA1c levels have lower quality of life than their counterparts, this being consistent with the previous reports [41–44]. Better glycemic control, assessed by HbA1c, has been reported in association with lower emotional distress, better well-being, better health status and better quality of life [45].

The association between age and quality of life was inconsistent. A previous study reported that older age was significantly associated with good quality of life in adults with T2DM [42]. The other studies reported that old age correlated with decreased quality of life [7,46,47]. However, our study found no relationship between age and quality of life. Age may not be specific for HRQoL in T2DM patients [48] and quality of life depend on diabetes-related complications rather than age [31]. Moderate or regular drinking was reported to help improve quality of life in healthy people [49,50], consistent with our study. However, this positive relationship in our study may be because alcohol drinkers were young, mostly males, and with few comorbidities or diabetes-related complications.

This study has some limitations. First, as a cross-sectional study without long-term follow-up, we cannot evaluate the causal relationship between poor sleep quality and quality of life. Second, we did not include hypoglycemia in our study, which was reported as a risk factor for poor quality of life in an earlier study [37]. Third, the sleep quality was subjectively assessed and no objective measures of sleep were available. Consequently, we are unable to ascertain the underlying causes of insomnia in this population. Additionally, it was not possible to assess and control for all variables that may affect sleep quality and quality of life, although our study has controlled some potential confounders.

In summary, we found that poor sleep quality is prevalent in Chinese diabetic patients. Poor sleep quality, diabetes-related complications, depressive symptoms and anxiety are associated with lower DSQL which therefore influence the quality of life in T2DM patients. Screening and management for poor sleep quality is necessary to be involved in T2DM patients' self-management to improve their quality of life.

Author contribution

P.L. researched data, contributed to the discussion, and wrote the manuscript. Y.Q. researched data, contributed to the discussion, and wrote the manuscript. L.Z. and Q.C. researched data, contributed to the discussion, and edited the manuscript. P.C. and P.Z. researched data, contributed to the discussion, and edited the manuscript. T.L. contributed to the discussion and edited the manuscript. Q.C. and Z.D. researched data, contributed to the discussion, and edited the manuscript.

Conflict of interest statement

There are no conflicts of interest and the manuscript has been read and approved by all authors.

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